Chapter

Impact of Off-Season Summer Tomato Cultivation on Income and Food Security of the Growers

Md. Sadique Rahman and Debasish Chandra Acharjee

Abstract

Vegetable production can help farmers to generate income, which will eventually alleviate poverty and malnutrition. Tomato is one of the most important vegetables in Bangladesh. But tomato production is extremely sensitive to hot and wet growing conditions. Thus, few varieties of off-season summer tomato have been developed and disseminated. Keeping these factors in consideration, this chapter was designed to delineate the impacts of summer tomato adoption on the income and food security status of the growers in a region of Bangladesh. Findings indicated that off-season tomato growers received significantly higher income. Consumption expenditure and food security status of the off-season tomato growers were significantly higher than non-growers. The chapter also includes policy implications for further development of the technology.

Keywords: Bangladesh, food consumption score, off-season, summer tomato, well-being

1. Introduction

Bangladesh's agriculture contributed around 16% of the country's GDP and currently employs around 45% of the country's labor force [1]. Crop sector in Bangladesh is characterized by rice monoculture, which has led to a number of serious physical and biological problems, including nutritional impact [2]. However, recently, emphasis is also shifting from basic nutrients to balanced diets. Vegetables can play an important role by providing high nutritive value food and higher returns that eventually alleviate poverty. Due to favorable climatic and soil, a large number of vegetables are cultivated throughout the year in Bangladesh. In a view of increase in income, employment, and reduction of widespread malnutrition in Bangladesh, there is a strong need for vegetable cultivation.

Among the vegetables, tomato is one of the most important vegetables by acreage, production, yield, commercial use, and consumption. Tomato is cultivated all over the country due to its adaptability to wide range of soil and climate [3]. Its demand for both domestic and foreign markets has increased manifold due to its excellent nutritional and processing qualities [4]. In Bangladesh, congenial atmosphere remains for tomato production during low temperature winter season, that is, early November is the best time for tomato planting in Bangladesh [5]. Tomato

plants are highly sensitive to hot and humid seasons. However, limited attempt has been made to overcome this high temperature barrier.

Considering the growing demand and importance of tomato, Bangladesh Agricultural Research Institute (BARI) has developed and disseminated few varieties of off-season summer tomatoes. This summer season tomato cultivation requires complex agronomic management including high labor and applications of growth regulators in addition to extended skill and knowledge. Farmers typically plant off-season tomato varieties in the middle of May and continued cultivation up to February in the following year. To protect tomato plants from monsoon rain, farmers construct a bamboo pole frame and slats to which a polyethylene hoop-shaped roof is attached [6]. The farm-level adoption of these varieties has already created a wide range of socioeconomic impacts that need to be evaluated properly to understand the output of research and development. So far, very little information is available on the impact of off-season tomato cultivation in Bangladesh.

Cultivating summer tomatoes in Bangladesh holds promise as a profitable enterprise with which farmers can augment the existing cropping patterns since only small amounts of land are required [6–8]. A study was conducted in southwestern Bangladesh to quantify the effect of training farmers on off-season vegetable cultivation. Findings indicate that training increased the net household income by about 48%. There was a significant increase in pesticide use and although there was an improvement in pesticide-handling practices, trained farmers may have been more exposed to pesticide health risk [9]. Majority of the off-season tomato growers possessed high knowledge on summer tomato cultivation. Education, land possession, annual family income, and extension contact of the farmers had a positive significant relationship with the farmers' knowledge on summer tomato cultivation [10]. Attack by pest and disease, lack of seed at proper time, lack of agricultural credit, and high cost of production were the major constraints for the adoption of summer tomato.

From the above discussion, it is clear that impacts of off-season tomato cultivation have not been addressed well in Bangladesh. Studies only measure the profitability using a very small number of samples. Thus, the questions like "What is the impact of off-season tomato cultivation on income and food security status?" are yet to be studied empirically in Bangladesh. This chapter is a moderate effort to examine the above research question and fulfill the gaps to some extent. It is expected that the findings will help the scientists and policy makers to further develop the technology.

2. Production technology of off-season tomato

Summer tomato cultivation in Bangladesh is mainly constrained by the seasonality and frequent attack of diseases. During the summer, fruit settings were disrupted due to high daytime temperatures above 26°C and at night temperatures above 20°C [11]. To overcome this problem, Bangladesh Agricultural Research Institute (BARI) has developed few hybrid varieties of heat tolerant tomato, known as off-season summer tomato [6]. High to medium land is required for summer tomato cultivation. Tomato may be grown on a wide range of soil from sandy to clay. The raised bed planting can be adopted in low land tropics and high rainfall areas. Transparent poly tunnel with a height of 120-180 cm was built on the raised beds to protect the tomato plants from rain. Approximately 75 cm wide drainage channel need must be constructed between tunnels to facilitate irrigation, drainage, and other intercultural operations [6].

3. Data sources and analytical techniques

The present study mainly used primary data to achieve the objectives. The primary data was collected from Jashore region (**Figure 1**) of Bangladesh due to the higher concentration of off-season summer tomato cultivation [6, 8]. At first, summer tomato cultivating villages was selected and for those villages a complete list of the off-season summer tomato growers was prepared taking help from local agricultural extension office. From that list, a total of 100 farmers were selected randomly as growers of summer tomato to collect the information regarding off-season tomato cultivation. These farmers were trained by different organizations on management aspect of summer tomato cultivation. Besides 150 farmers who

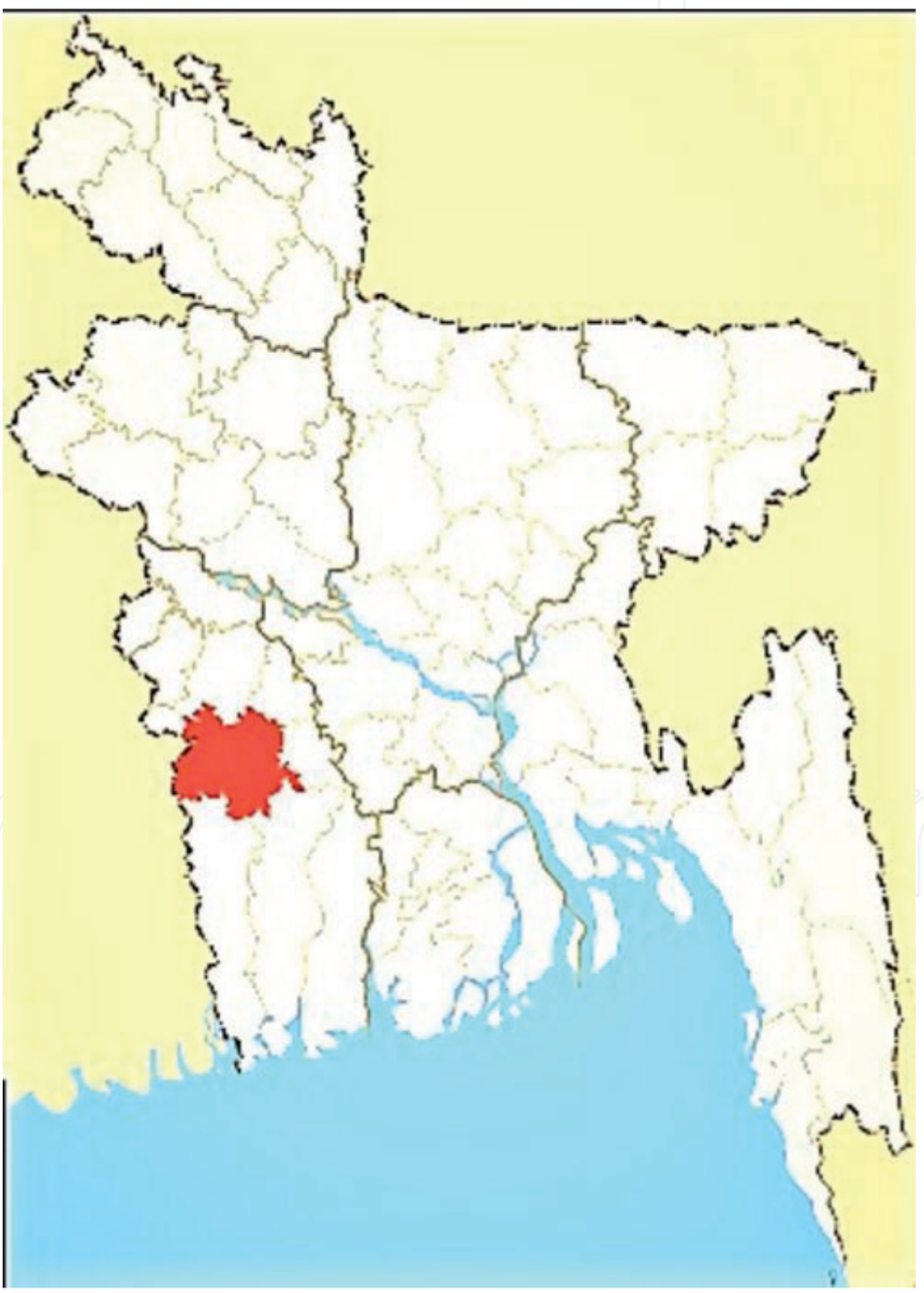

Figure 1.
Location map.

did not cultivate off-season summer tomato but had suitable land and interest in growing summer tomato were selected randomly for interview as non-growers of the technology. The non-growers grew winter tomato and also did not receive any training on summer tomato cultivation. Thus, a total of 250 farmers were selected randomly for the face-to-face interview.

The present study employed propensity score matching (PSM), inverse probability weighting (IPW), and inverse probability weighted regression adjustment (IPWRA) techniques to achieve the objectives. PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment, using observed characteristics [12]. According to Heckman et al. [13], the basic assumption of using a counterfactual is that the untreated samples approximate the treated sample if they had not been treated, that is, $E(Y_{0i} T = 1)$. The validity of PSM depends on two condition; conditional independence assumption (CIA) and sizable common support in propensity score across the growers and non-growers. The CIA argues that program outcomes are independent of program participation conditional on a set of observables (X). When CIA condition is not met, it is assumed that may be unobserved factors affect the outcome and treatment assignment, leading to a hidden bias [14]. Under the CIA, the average treatment effect on treated (ATT) was computed as:

$$ATT = E(Y_1 - Y_0 \mid X, T=1) = E(Y_1 \mid X, T=1) - E(Y_0 \mid X, T=0) \quad (1)$$

Balancing properties need to be satisfied for PSM to be valid which implies that for observation with the same propensity score, the distribution of pretreatment characteristics must be same across growers and non-growers' group. Another requirement for PSM is common support or overlap condition. It implies that farmers with same X values have positive probability of being both grower and non-grower. Three matching algorithms: nearest neighbor, radius matching and kernel matching were used to present the findings of the study.

IPW uses the inverse of the propensity score as weights in calculating the average value of the outcome variable [15, 16]. IPW does not match off-season tomato growers with non-growers. In IPW, farmers with low predicted probability receive a lower weight while farmers with high predicted probability of adoption receive a higher weight.

True measurement of impacts requires controlling of sample selection bias through random assignment of individuals into treatments. However, ATT from PSM and IPW can still produce biased results in the presence of mis-specification in the propensity score model [17, 18]. To overcome the problem, the present study used IPWRA which has the double-robust property that ensures consistent results as it allows the outcome and the treatment model to account for mis-specification. ATT in the IPWRA model was estimated in two steps. In the first step, we estimated the propensity scores using binary probit model and in second step, linear regression was used to estimate the ATT.

To assess the impact three outcome indicators were selected. Income from off-season tomato (Tk./ha): The sum of crop output minus the value of variable inputs (fertilizers, pesticides, seeds, hired labor, etc.) and fixed inputs. This is the net income households receive from off-season tomato cultivation (Tk. is Bangladeshi currency, 1 USD = Tk. 85). Consumption expenditure (Tk./adult): Total expenditure on consumption per adult per year was calculated. Food security status: Food security status of the farmers was assessed by using Food Consumption Score (FCS). The FCS of a household is calculated by multiplying the frequency of foods consumed in the last seven days with the weighting of each food group [19].

4. Profitability of off-season tomato cultivation

It is conspicuous from **Figure 2** that the average yield of summer tomato was 32.45 t/ha which was significantly higher than that of the winter tomato growers. In the winter season, farmers usually received Tk 10 as selling price of per kg tomato, while in the case of summer tomato farmers they received Tk. 38 per kg, which is substantially high. Due to higher productivity and price, the gross return for off-season tomato growers was also significantly higher. Higher gross return implies higher profit. Thus, off-season tomato cultivation may reduce poverty to some extent. **Figure 3** indicates that off-season tomato cultivation does not have any cost advantage. **Figure 4** indicates that tunnel preparation cost, human labor cost, and growth regulators were the major cost items for off-season tomato cultivation [6, 7]. It implies that off-season tomato cultivation is cost incentive and requires higher initial investment which confirms the findings of other studies [20, 21].

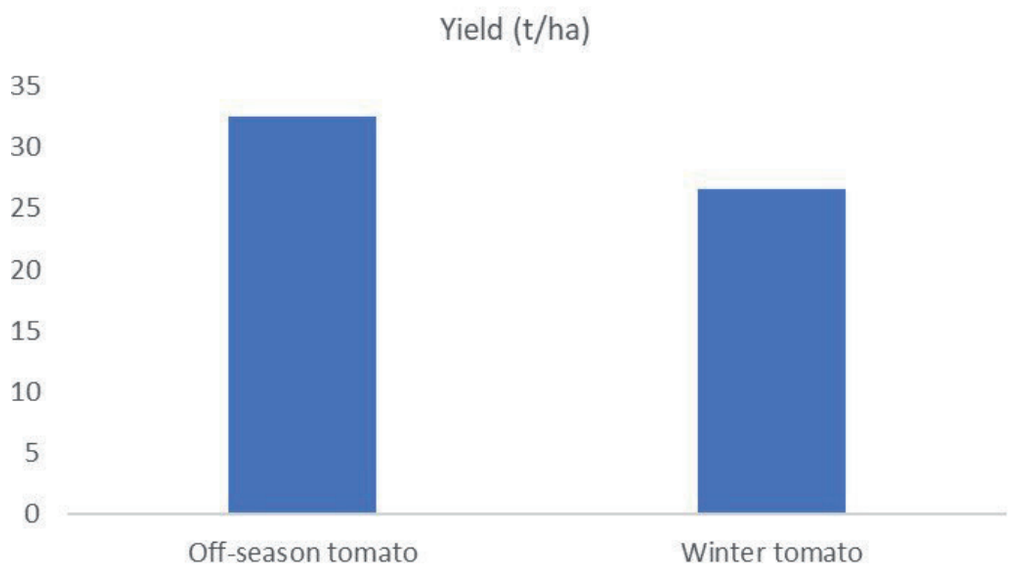

Figure 2.
Comparative yield of tomato.

Figure 3.
Comparative cost of production.

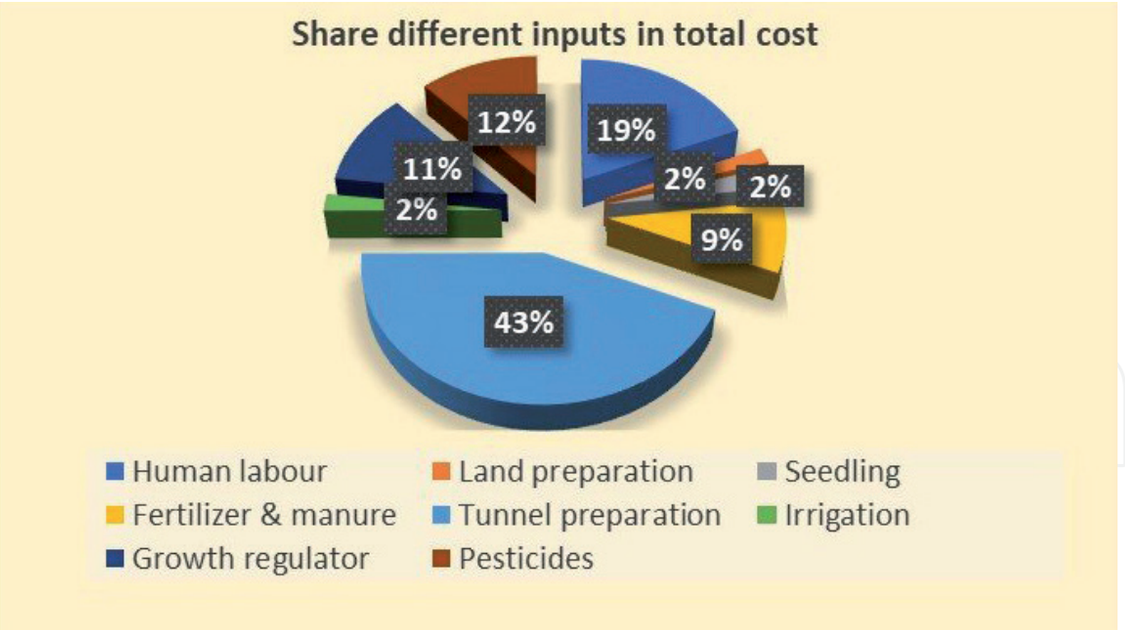

Figure 4.
Share of different inputs.

5. Impacts of off-season tomato cultivation

The off-season tomato growers received significantly higher income compared to non-growers (winter season growers) based on nearest neighbor, radius, and kernel matching (**Table 1**). This may be due to higher productivity and market price. Ali et al. [20] also indicated that off-season tomato cultivation is profitable. The ATT values were found to be Tk. 261,000, 253,000, and 261,000 based on nearest neighbor, radius, and kernel matching, respectively. The findings of IPW and IPWRA were similar to PSM which confirms the robustness of the results. The ATT values were Tk. 257,667, and 257,683 based on IPW and IPWRA, respectively. The income from off-season tomato cultivation can be further increased by improving management practices, such as timing of various growth regulators application [6, 22]. Thus, there is scope to raise the income reducing costs by appropriate management practice. The studies suggested that training on off-season tomato cultivation has significant impact of income [9]. Therefore, more efforts on trained farmers may also provide better results.

Models	ATT	SE	t-Value
PSM			
NN matching	261,000***	20,427	12.78
Kernel matching	253,000***	21,713	11.65
Radius matching	261,000***	18,406	14.19
IPW	257,667***	19,915	12.94
IPWRA	257,683***	20,101	12.82

*** *Indicates significant at 1% level.*
Nearest neighbor, kernel matching, and radius matching identified 34, 98, and 98 farmers as non-growers (control), respectively.

Table 1.
Impact of off-season tomato cultivation on income.

Models	ATT	SE	t-Value
PSM			
NN matching	10,183***	2520	4.04
Kernel matching	9346***	1491	6.26
Radius matching	7584***	1228	6.17
IPW	8545***	1410	6.06
IPWRA	8449***	1425	5.93

****Indicates significant at 1% level.*

Table 2.
Impact of off-season tomato cultivation on consumption expenditure.

Models	ATT	SE	t-Value
PSM			
NN matching	7.09*	4.47	1.59
Kernel matching	4.04	2.75	1.47
Radius matching	5.87***	1.85	3.16
IPW	4.63**	2.12	2.18
IPWRA	4.43**	2.17	2.03

**, ** and ***indicates significant at 10%, 5%, and 1% level, respectively*

Table 3.
Impact of off-season tomato cultivation on FCS.

The consumption expenditure per adult is also significantly higher for off-season tomato growers compared to non-growers based on nearest neighbor, radius, and kernel matching (**Table 2**). The findings of IPW and IPWRA were also similar to PSM which confirms the robustness of the results. The ATT values were found to be Tk. 8545 and 8449 based on IPW and IPWRA, respectively. Due to higher income off-season tomato growers were able to spend more on consumption. Karim et al. [7] also indicated that off-season tomato growers were able to increase their socioeconomic status due to higher income.

FCS was used as proxy to capture the impact of off-season tomato cultivation on food security of the growers. The findings of PSM analysis indicate that off-season tomato cultivation has significant effect on the FCS of the growers. FCS was significantly higher for off-season tomato growers compared to non-growers based on nearest neighbor, and radius matching (**Table 3**). The ATT values were 7.09 and 5.87 based on nearest neighbor and radius matching, respectively. The ATT values were also significant at the 5% level for the other two methods which confirm the robustness of the findings. Off-season tomato cultivation can be a useful way of increasing the income and food security status of the farmers. More awareness building programs and extension efforts are warranted to increase the area under off-season tomato cultivation.

6. Constraints of off-season tomato cultivation

Although off-season tomato cultivation is observed to be a profitable crop, but there are several constraints to its higher production. Eighty percent of the farmers reported frequent attack of insect and diseases was the major constraint that hinders the adoption and production confirm the findings of Ali et al. [20] (**Table 4**).

Items	Percent	Rank
Attack of insect and diseases	80	1
High price of growth hormone	75	2
High price of tunnel materials	60	3

Table 4.
Constraints of off-season tomato cultivation.

High price of tunnel materials and growth hormone require high cash amount for cultivation which in turns hinder the adoption process and production. More research on off-season tomato varieties is essential to optimize the technology.

7. Conclusions

It is evident that off-season tomato cultivation is profitable and has significant impact on the consumption expenditure and food security status of the farmers. Based on the results, a number of policy implications can be drawn. More investment in research and development is needed from both donor and government agencies to develop resistant varieties of off-season tomato since the farmers reported that frequent attack of insects and diseases was the main constraint of off-season tomato cultivation. Efforts are needed to disseminate the off-season tomato cultivation technique to different parts of the country. Cost of production is higher for off-season tomato cultivation compared to winter season tomato cultivation. Steps to diversify sources of income as well as access to low interest credit can increase the availability of capital. Higher income may have a positive effect on reducing poverty in the country. Higher consumption expenditure and food security status may play a vital role in reducing malnutrition. Thus, there is a need for promoting the role of off-season tomato cultivation in anti-poverty programs, especially in developing countries like Bangladesh.

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Conflict of interest

The authors declare no conflict of interest.

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References

[1] BBS. Yearbook of Agricultural Statistics of Bangladesh. Dhaka: Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh; 2015

[2] Saha N. An economic analysis of homestead vegetables production in some selected areas of Netrokona district [MS thesis]. Mymensingh, Bangladesh: Department of Agricultural Economics, Bangladesh Agricultural University; 2012

[3] Ahmed KU. Phul Phal O Shak Shabji (in Bangla). 2nd ed. Dhaka, Bangladesh: Farm Gate; 1976. p. 470

[4] Hossain MA, Goffer MA, Chowdhury JCS, Rahman MS, Hossain MI. A study on postharvest practices and loss of tomato in some selected areas of Bangladesh. Bangladesh Journal of Agricultural Research. 1999;**24**(2):299

[5] Hossain MM, Karim MK, Haque MM, Hassain AKMA. Performance of Some Promising Tomato Lines Planted at Different Dates. Gazipur: Annual Report, Vegetable Section, Division of Horticulture, Bangladesh Agricultural Research Institute; 1986. pp. 9-12

[6] Baksh ME, Rossi F, Krupnik TJ, Talukder ASMH, McDonald A. How much can smallholders in Bangladesh benefit from summer tomato cultivation? An applied agro-economic analysis of on-farm data. SAARC Journal of Agriculture. 2015;**13**:80-93 https://doi.org/10.3329/sja.v13i2.26570

[7] Karim MR, Rahman MS, Alam MS. Profitability of summer BARI hybrid tomato cultivation in Jessore district of Bangladesh. Journal of Agriculture and Rural Development. 2009;**7**(1&2):73-79. DOI: 10.3329/jard.v7i1.4424

[8] Hajong P, Sikder B, Mondal S, Islam MA. Adoption and profitability of summer tomato cultivation in Jashore district of Bangladesh. Bangladesh Journal of Agricultural Research. 2018;**43**(4):575-585. DOI: 10.3329/bjar.v43i4.39154

[9] Schreinemachers P, Wu M, Uddin MN, Ahmed S, Hanson P. Farmers training in off-season vegetables: Effects on income and pesticide use in Bangladesh. Food Policy. 2016;**61**:132-140. DOI: 10.1016/j.foodpol. 2016.03.002

[10] Monalesa N. Farmers' knowledge and attitude towards summer tomato cultivation [MS thesis]. Dhaka, Bangladesh: Department of Agricultural Extension and Information System, Sher-e-Bangla Agricultural University; 2014

[11] Zaman MM, Huq SMA, Chowdhury MJA. Production potentiality of summer tomato in Jamalpur region. International Journal of Sustainable Crop Production. 2006;**1**(2):12-15

[12] Khandker SR, Koolwar GB, Samad HA. Handbook of Impact Evaluation; Quantitative Methods and Practice. Washington DC: The World Bank; 2010

[13] Heckman JJ, Ichimura H, Todd P. Matching as an econometric evaluation estimator. Review of Economic Studies. 1998;**65**:261-294

[14] Caliendo M, Kopeinig S. Some practical guidance for the implementation of propensity score matching. Journal of Economic Surveys. 2008;**22**(1):31-72. DOI: 10.1111/j.1467-6419.2007.00527.x

[15] Wooldridge JM. Inverse probability weighted estimation for general missing

data problems. Journal of Econometrics. 2007;**141**:1281-1301. DOI: 10.1016/j.jeconom.2007.02.002

[16] Imbens G. Nonparametric estimation of average treatment effects under exogeneity: A review. Review of Economics and Statistics. 2004;**86**(1):4-29. DOI: 10.1162/003465304323023651

[17] Robins J, Sued M, Lei-Gomez Q, Rotnitzky A. Comment: Performance of double-robust estimators when "inverse probability" weights are highly variable. Statistical Science. 2007;**22**(4):544-559. DOI: 10.1214/07-STS227D

[18] Wooldridge JM. Econometric Analysis of Cross Section and Panel Data. 2nd ed. London, England: The MIT Press; 2010

[19] WFP. Food Consumption Analysis Calculation and Use of the Food Consumption Score in Food Security Analysis. Rome: World Food Programme, Vulnerability Analysis and Mapping Branch; 2008. Available from: https://www.wfp.org/content/technical-guidance-sheet-food-consumption-analysis-calculation-and-use-food-consumption-score-food-s

[20] Ali Q, Ashfaq M, Khan MTI. An economic analysis of off-season tomato production in Punjab. The Journal of Animal & Plant Sciences. 2017;**27**(1):294-301

[21] Adenuga AH, Lawal AM, Rotimi OA. Economics and technical efficiency of dry season tomato production in selected areas in Kwara State, Nigeria. Agris On-Line Papers in Economics and Informatics. 2013;**5**:11-19

[22] Chen JT, Hanson P. Summer Tomato Production Using Fruit-Setting Hormones. AVRDC Publication No. 01-511. Taiwan: Asian Vegetable Research and Development Centre (AVRDC); 2001